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Pleistocene bow-hunting in Africa and the human mind

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Advances in genetic research and palaeoneurology, together with a better understanding of the African archaeological record, demonstrate that aspects of the sapient mind evolved in Pleistocene Africa. Complex, bimanual technologies, operated over a distance – such as bow-hunting – may provide a partial window into human cognitive evolution. I report on recent interdisciplinary research, drawing on: (1) the development of the human precuneus as the brain region that facilitates visuo-spatial integration; (2) sport psychology and cognitive-motor neuroscience; and (3) neuro-genetic adaptations towards human attention. This research highlights the role of the precuneus and attention in modern archery, and the variation in the genetic development of attentional resources in African *Homo sapiens* in comparison with the Neanderthals and Denisovans of Eurasia, which may explain why bow-hunting was an African Pleistocene invention.

Significance:

The bow-and-arrow may have been invented in sub-Saharan Africa by ~80–60 ka. Complex technologies of this time depth have the potential to inform about the evolution of the human mind. I highlight the precuneus as the brain region, and at least 14 'attention genes' selected for in the *Homo sapiens* genome, that may have facilitated early African bow-hunting.

Introduction

Until recently, it was thought that Africans who lived during the Middle Stone Age about 300–30 ka were ineffective hunters lacking the bow-and-arrow[1], perhaps because they lacked the necessary cognitive capacity. Yet, Middle Stone Age faunal remains tell a different story (see SOM data 1 in Sahle and Lombard[2]), as does the human fossil record (Figure 1). The African *Homo sapiens* genetic record also stretches back to ~350–260 ka[3], with behavioural modernity recognised since ~100 ka[4]. The earliest evidence for stone-tipped hunting weapons, at ~500 ka, currently comes from South Africa.[5] Cold phases possibly stimulated weapon development, so that by Marine Isotope Stage (MIS) 12 (478–424 ka), African *Homo heidelbergensis* preferred hunting with thrusting spears complimented by stabbing spears.[2] By MIS 8 (300–243 ka), with the appearance of *Homo sapiens*, people seem to have started experimenting with javelin hunting over longer ranges of >20 m, and, by MIS 5 (123–71 ka), we possibly see the first tentative experimentation with bow-hunting, which seems to become well developed by MIS 4 (71–57 ka).[2]

We cannot excavate the ancient human mind, but complex techno-behaviours such as bow-hunting may reveal something about its evolution in Africa.[6] Malafouris[7] applied Material Engagement Theory to explain how the use of technology shapes the brain and how it thinks. The things we do habitually are expressed in both our technologies and our brains, and changes in one may prompt changes in the other.[7] Today, cell phones, computers and gaming devices are changing human neurology, behaviours, and perhaps the evolution of our species.[8] If technology is changing our brains today, there is no reason to think it did not happen in the past.

Bow-hunting in the human precuneus

The globularisation of the sapient cranium, with an expansion of the precuneus, becomes recognisable in the Old World *Homo sapiens* fossil record between ~160 ka and 100 ka[9], long after our split from the Neanderthals and Denisovans at ~700–500 ka (Figure 1). The precuneus is active during cognitive processing in modern archers[10], serves as an interface between action and cognition in higher-order, bimanual coordination[11], and damage to the precuneus causes impairment in bimanual synchronisation[12]. Such coordination develops incrementally into adulthood, improving with inter-hemispheric communication via the corpus callosum, and with the ability to focus attention through time and across space.[13] The precuneus, along with other parts of the human brain, also shows the most activation when spatial attention is needed during tool use.[14] It is part of the brain's default-mode system, with extensive network activity and structural connectivity.[15] The frontal region mostly facilitates body cognition, the posterior region visual cognition, the middle portion integrates internal and external signals, and the inner area links

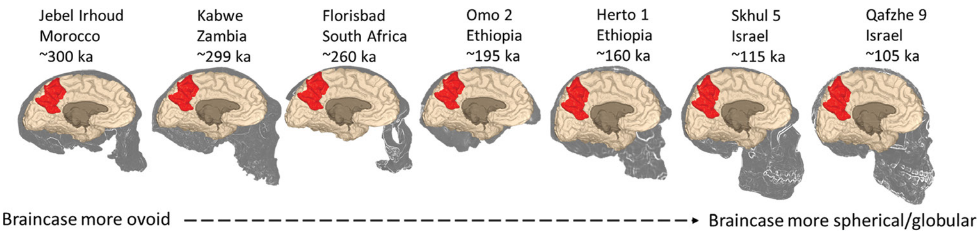
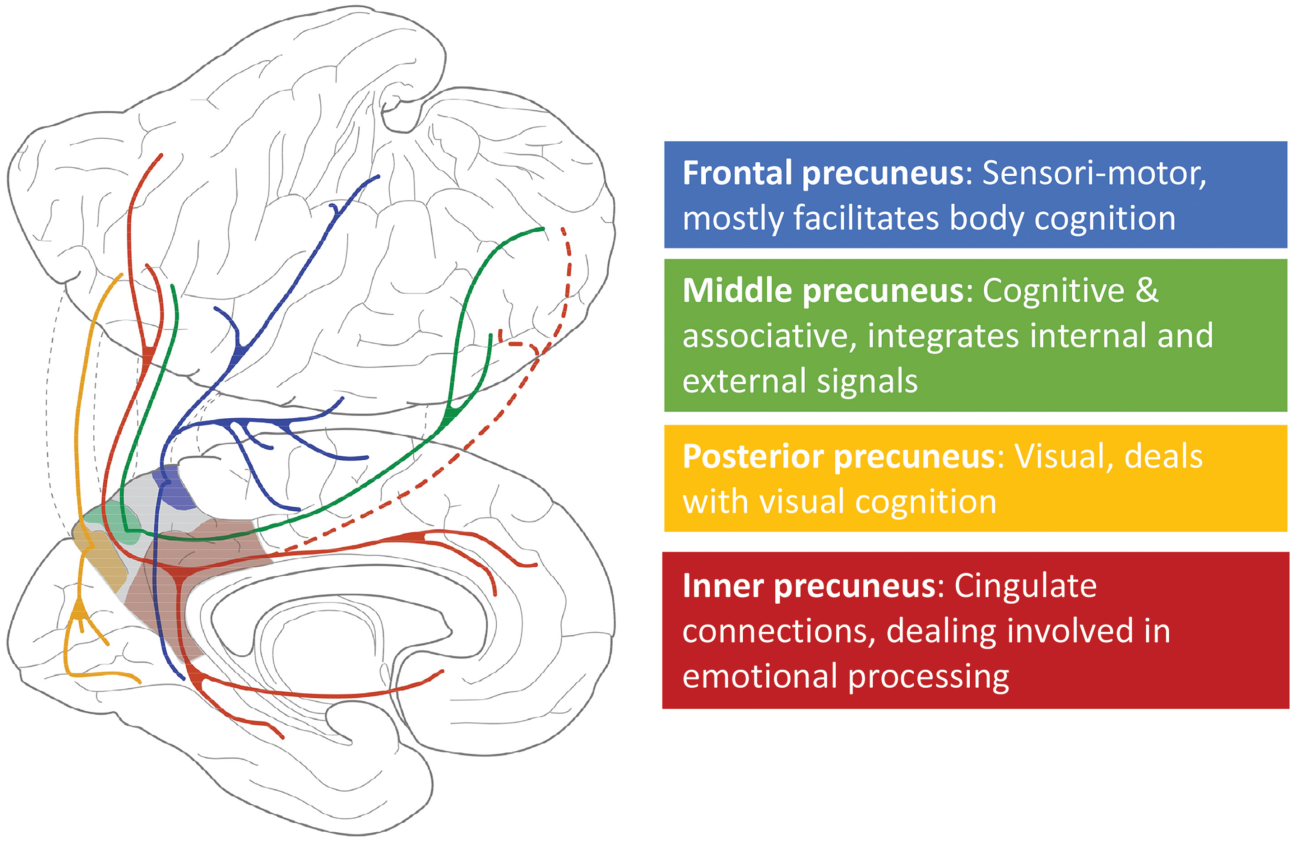


Figure 1: Cranial fossil record of *Homo sapiens*, showing the globularisation of the human brain and expansion of the precuneus (red area).



Source: Image adapted from Beldenpoint[17] (reproduced under a CC BY 3.0 licence); annotations by M.L.

Figure 2: Inter-connectivity of the human precuneus (adapted from Margulies et al.[15]), with intra-precuneal functional regions. The grey area represents the precuneus in the human brain, with the frontal precuneus indicated in blue, the middle precuneus in green, the posterior precuneus in yellow and the inner precuneus in red. The main interconnectivities of each precuneal area with other brain areas are displayed in the same colour as are their main functions in the bars to the right of the brain schematic.

to emotional processing (Figure 2). The result is visuo-spatial integration functioning as a bridge between embodied experience, emotion and cognition.[16]

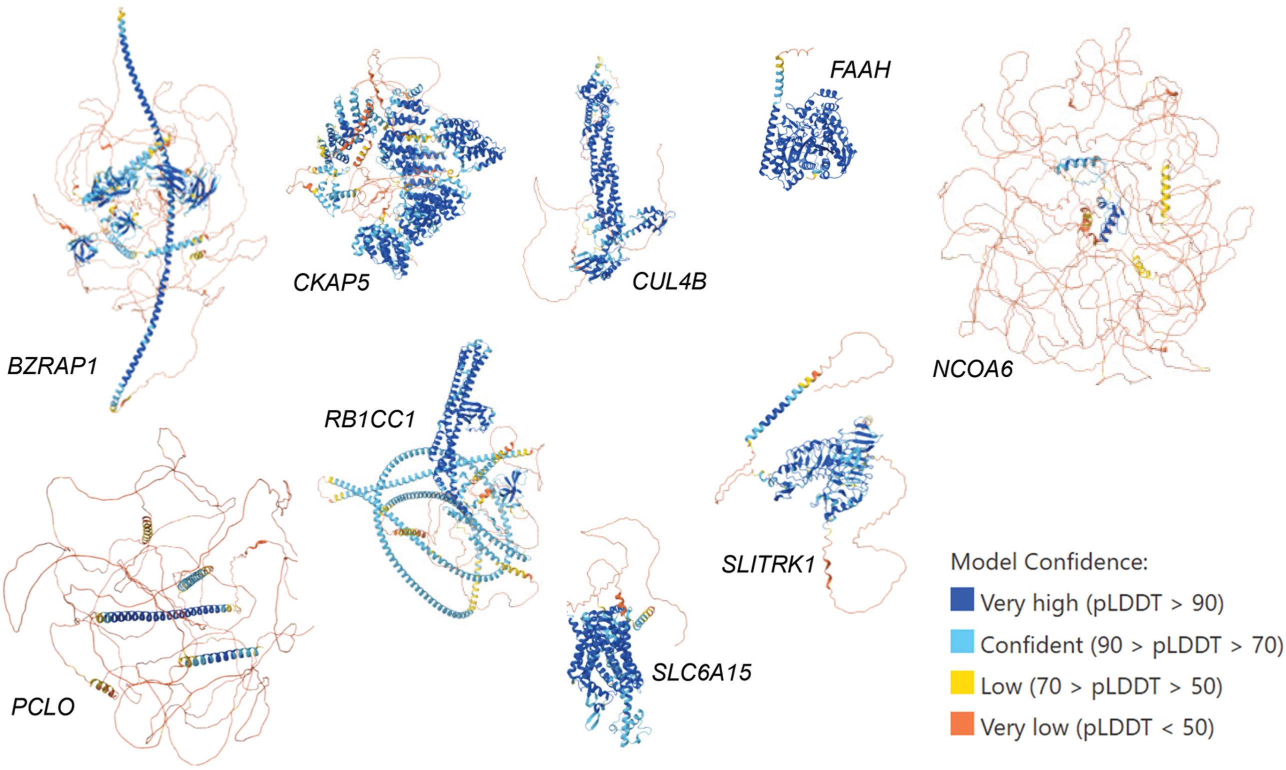
During modern archery, visuo-spatial integration facilitates: (1) the space–time understanding of physical body–environment coordination; (2) the assimilation of visual images with conscious, self-centred episodic memory recall; and (3) multivariate mental experiments or imagining 'what if' scenarios when planning a shot. During bow-hunting, the precuneus, with its network, would be involved in: (1) storing visuo-spatial information about limb and hand positions, and hand–tool interactions; (2) facilitating shifts in attention between the embodied location of the hunter and the location of the prey animal on the landscape; (3) predicting the flight of the arrow and prey movement; and (4) focusing the mind to take an accurate shot.[9] According to Bruner[18], similar levels of visuo-spatial integration, conscious embodied experience, emotional control, attentional shift and focus, i.e. similar 'mindfulness', is not possible without the developments observed in the sapient precuneus by ~100 ka. Today, our ability to focus attention in multiple ways enables us to conduct both mundane and complex tasks. It is key to successful bow-hunting, but focusing and sustaining attention requires training.

Attention in the archer's brain

Liu et al.[19] demonstrated how 45 minutes of Chinese archery improves attentional and emotional control, working memory and cognitive flexibility in pre-adolescent children. Sports psychology and cognitive-motor neuroscience help to observe variation between highly practised and beginner performances and their neuroanatomy.[20] Practising archery stimulates the processing of information from both within and outside the archer's brain, simultaneously selecting and filtering stimuli. This allows the archer to focus attention on multiple aspects relevant to firing a successful shot, whilst ignoring or buffering distractions.[21] The ability to pay attention in such a complex manner is key to sapient cognition today. Neurocognitive work suggests that repeated practice and improvement in aiming accuracy result in plastic changes in brain areas associated with spatial attention.[10] Kim et al.[22] performed a functional magnetic resonance imaging study, comparing differences in the neural networks of expert archers and novice archers during the aiming process. They found that the precuneus was one of the areas of the brain with significantly higher activation compared to other regions in the brains of expert archers, and even more active in the brains of novice archers compared to experts when aiming.[20,22] This suggests that the sapient precuneus probably also plays a role in bow-hunting (Figure 3), and that complex, attention-demanding tasks such as bow-hunting may stimulate development/changes in the precuneus and its associated attentional networks.[6]

Source: Raats[23] (reproduced under a CC BY 2.0 licence)

Figure 3: Kalahari Khomani San, Boesmansrus Camp, Northern Cape, South Africa.



Source: Adapted from AlphaFold Protein Structure Database[26] (reproduced under a CC BY 4.0 licence)

Figure 4: Three-dimensional protein structures of genes, associated with the precuneus and attention, selected for in *Homo sapiens* since our split from the Neanderthals and Denisovans.

Neurogenetic adaptations towards human attention

We are also able to trace neurogenetic adaptations in human cognitive evolution. Kaczanowska et al.[24] showed that functional networks started to change from motor control to attention by >18 Ma in ancient hominoids and by >7 Ma in ancestral Homininae. Much later (~700–500 ka), the Neanderthal split from a common *Homo* ancestor shows genetic selection for strategic thinking (prospection/theory of mind), working memory and mathematical skill.[24] The Denisovans, who split from the Neanderthals after 500 ka, clustered with functional networks for motor control, affective attention (introspection), affective processing (impulse/emotional control), active and passive attention, and action planning.[24] After ~300 ka, *Homo sapiens* in Africa show continued selection for working memory, fine motor control, language, emotion recognition, relational processing (causal cognition), abstract thinking and a notable emphasis on strategic thinking.[24]

Of 44 genes listed as associated with Neanderthal, Denisovan and *Homo sapiens* cognition[24,25], 26 are associated clinically with attention[20]. Of these 'attention genes', none was selected for in all three groups. Five attention genes (*ADAMTS9, ARHGEF11, CHL1, LAMB3, MKKS*) were selected for in both *Homo sapiens* and Denisovans. The *ADGRV1* gene was selected for in both Neanderthals and *Homo sapiens*. Fourteen of the attention genes (*ASTN1, BZRAP1, CKAP5, CUL4B, FAAH, LPHN3, MCPH1, NCOA6, NUP210, PCLO, PCNT, RB1CC1, SLC6A15, SLITRK1*) currently associated with neurogenetic selection for human cognitive evolution[24,25] were selected for only in *Homo sapiens*. Nine of these (*BZRAP1, CKAP5, CUL4B, FAAH, NCOA6, PCLO, RB1CC1, SLC6A15, SLITRK1*) have been linked to cognitive processing in the precuneus (Figure 4; also see Lombard's[20] table 2) – which is associated with activation and neuronal pressure when bimanually aiming an arrow at a target through space.[19,21] Different neurogenetic pathways are therefore indicated for developing the ability to pay attention amongst ancestral humans, and may explain why only *Homo sapiens* became habitual bow-hunters during the African Pleistocene (see Lombard[6] for a more extensive gene list associated with the precuneus and methodological discussion).

In conclusion

Today, the human brain–body–tool interface depends on multiple attentional resources, allowing us to coordinate our actions, and plan and direct motoric tasks whilst integrating tools into our body and neural schemes.[25] Noticeable changes in Pleistocene technology may demonstrate parallel changes in human attention, ultimately leading to the techno-behavioural complexity observed in the *Homo sapiens* hunter–gatherer record since ~100 ka.[4,27] The origin of bow-hunting in Africa, sometime between ~80 ka and 60 ka, represents a major change in human techno-behaviour that is, thus far, exclusive to *Homo sapiens*. Neurocognitive work reveals that attentional resources are developed through practising. It demonstrates that paying attention whilst aiming an arrow stimulates the precuneus – a brain region that only reached its modern range by ~100 ka.[16] If practising a bimanual technology over a distance, such as archery, changes how an archer's brain is able to pay attention today, there is no reason to think that ancient *Homo sapiens* brains did not go through similar neuroplastic adaptations when using similar technologies.

Data availability

There are no data pertaining to this article.

Declarations

I have no competing interests to declare. I have no AI or LLM use to declare.

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